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LIFE IN OTHER WORLDS.[1]

By H. C. Wilson.

The question asked of the astronomer, more frequently perhaps than any other by the average visitor to an observatory, is that concerning the "man in the Moon." Though jokingly asked in general, and sometimes in all seriousness, it always implies a serious question, which naturally arises in the mind of one who thinks on things celestial, concerning the possibility of life like our own in other worlds. Are all the planets which circle around the Sun, or any of them, the abodes of living, sentient beings? Are those beings like ourselves? Are they engaged in similar pursuits? Do they till the soil, sow and reap, buy and sell and get gain? Have they learned men, prying into the secrets of the universe with microscope and telescope? Are they looking down at us and wondering whether on this little Earth we know as much as they do? Or, among the millions of orbs which sweep through limitless space, is the little world on which we stand the only one which has been honored by the Creator with the creation of "man in his own image"?

Fruitless questions these, you may say, which it is impossible to decide. True. Still, these are things we would like to know and we shall be justified in throwing all the light we can upon them. Of late the studies of the planet *Mars* have drawn attention to the similarity of its physical condition to that of the Earth, and there have been suggestions of methods of interplanetary communication. The newspapers a few years ago circulated reports to the effect that a certain astronomer had seen lights flashing from *Mars* in such a manner as to suggest to him a system of signals; in other words, that the Martians were attempting to telegraph to the inhabitants of the Earth, or some other planet, after the manner of our army signal service. Though this was all a hoax, the thought has been taken up, partly in jest, partly in earnest, and schemes have been suggested for signalling back to the Martians by series of flashes from powerful condensers at the extremities of a great triangle upon the Earth's surface. One lady was so impressed by these suggestions that at her death she left the sum of 25,000 francs to the Institute de France, to be used in carrying out the experiments. Of course nothing could come from such attempts, and I do not suppose they will ever be made, but the thoughts are interesting and might be made the basis of a popular novel.

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[1] Read before the Astronomical Society of the Pacific, March 25, 1911.

Into the *a priori* arguments in favor of or against the belief that the other planets are inhabited I have not time to enter. The principal argument in favor is that from analogy. Everywhere in the Earth we find evidence that the purpose of its creation was to sustain life. The planets are like the Earth, and therefore must have been made for the same purpose. The stars are like the Sun, and doubtless like it have planets revolving about them; and so throughout the infinite universe "the heavens declare the glory of God" through the medium of infinite myriads of living souls, each capable of rendering the homage due to its Maker, and of comprehending to a limited extent His wondrous works. On the other hand, to some minds it does not seem at all necessary to the glory of God that His works should be seen and appreciated by human eyes.

The elaboration of these two views would be exceedingly interesting, but I must confine myself to the discussion of the facts, which have been derived from observations with telescope and spectroscope, concerning the physical condition of the planets, and their bearing upon the question of habitability. I say habitability, for I do not think we shall ever be able to say positively that any of the planets *are actually inhabited.* We shall by no increase of magnifying and defining power of telescopes ever be able to actually *see* the inhabitants. This is not because we have reached the limit of magnifying power, but because of the great turbulent ocean of atmosphere through which we must look, and which is almost incessantly in motion, bending and intermingling the rays of light which come to us, so that the minute details of a planet's surface are hopelessly blurred. The more we magnify them the worse they are blurred. On exceedingly rare occasions this sea of air quiets down and permits the astronomer to use the full power of his instrument. The astronomer is happy if at these times he is free to devote his attention to those objects which are most attractive to the sight. Occasionally such opportunities come to us at Goodsell Observatory. One in particular I call to mind. Visitors were present, and soon the clouds came over, but in the few minutes granted to us we saw minuter detail in the depths of some of those giant craters on the Moon than we had ever seen before. Fine, however, as these details were, they were far too coarse to indicate the presence of men, or elephants, or even individual houses and trees. With the highest power we can use on our 16-inch telescope, the Moon is brought within one hundred and fifty miles, i. e. its apparent size in the telescope is as large as it would be to the naked eye if the Moon were actually one hundred and fifty miles away. The great Lick telescope in its favorable position on a mountain, above the worst of the atmospheric disturbances, will at best bring the Moon within sixty miles. You know how little can be seen at that distance. A man, to be seen with the unaided eye, must be within ten miles distance. Theoretically, a telescope could be constructed of sufficient power to bring the Moon within ten miles, but at the summit of the highest mountain on the Earth, there would still be air enough (as well as sufficient lack of air) to prevent its use. We must then give up all hope of seeing living beings on the Moon, our nearest neighbor, much more so on the other planets.

Inquiring into the physical conditions of the planets, as suitable to the sustenance of life or not, we find first upon the Moon *no air*. At least the atmosphere is thinner than that in the most perfect vacuum which we can produce by means of an air-pump. The rays of light from stars, when the Moon passes them, suffer no change, either of intensity or direction, until they are instantly cut off by the solid edge of the Moon. There are no clouds and no water. Air and water have apparently all been absorbed into the solid crust of our satellite. Without air and water, no vegetation can exist. There is no soil other than volcanic ashes. The surface is exceedingly rough and broken, the greater portion completely covered with crater rings and cones, lava ridges and mountains. Great yawning cracks and chasms abound, thousands of yards wide and of unknown depth. The temperature is intensely cold. The rays of the Sun beat down fiercely upon the surface unrestrained by the blanket of air and vapor which on the Earth both tempers and retains the heat, but the absence of this blanket allows the heat on the Moon to be almost immediately radiated into space. According to the most recent investigations, the temperature of the lunar surface even during the long day (fourteen of our days) of continuous sunshine does not rise above the freezing point. And during the equally long night it must fall appallingly low. Surely this is not the place to look for life like ours.

The Sun, I suppose, may be left out of consideration. A ball of gas, having a surface temperature estimated at about 10,000 Fahrenheit, would not be likely to be a comfortable place to live. Yet the theory has been entertained, by so great an authority as Sir WILLIAM HERSCHEL, that there might be a cool body within the Sun, protected in some way from the intense heat of the exterior, so that life would be possible and comfortable. What kind of an envelope could possibly be sufficient to protect the interior from the immense radiation of the exterior, which is found to be about 10,000 horse-power per square foot, has not been satisfactorily explained.

Passing outward from the Sun, the first planet we come to is *Mercury*. Until recently but little was known of the physical condition of this planet. Its orbit is so near the Sun that observations of its surface are obtained only with difficulty and under unfavorable circumstances. In 1881-2, however, SCHIAPARELLI succeeded, by midday observations in the transparent sky of Italy, in identifying certain markings on *Mercury's* surface which led him to the conclusion that the planet rotates upon its axis in the same time that it revolves about the Sun, thus keeping always the same side toward the Sun. More recently this conclusion has been verified by LOWELL'S observations at Flagstaff, Arizona, and it is probably to be accepted as a fact, although it is not yet admitted by all astronomers. If it be true, this fact has an important bearing upon the subject we are discussing. If the planet always keeps the same side toward the Sun, there will be on the one hemisphere eternal day, on the other everlasting night. We can imagine what would be the effect upon the Earth if the Sun were to stop its diurnal course through the sky and become stationary near the zenith. Without the alternation of day and night, a continuous noon-day Sun boiling down fiercely year after year would raise the temperature to a frightful height. Multiply the intensity of the rays of the tropical midsummer Sun by nine and you will have some idea of those which beat down upon the sunward side of *Mercury*. On the other side would be the opposite extreme, unbroken night and a temperature practically as low as that of space. On the margin of the two hemispheres would be a zone 47° wide which would be alternately in sunshine and in darkness in the period of the planet's revolution, eighty-eight days. The Sun does not stand stock still in the sky, but nods back and forth, east and west, through an arc of 47°, because of the planet's varying speed in its quite elliptic orbit, while its rotation is uniform. We perhaps might suppose that the middle portion of this zone of alternate sunlight and darkness might be endurable by beings like ourselves, so far as heat and cold are concerned, but it is probable that *Mercury*, like the Moon, has little if any air and water. Having only one twenty-first of the mass of the Earth, *Mercury's* gravitation is theoretically insufficient to retain much of an atmosphere, and according to LOWELL's observations, there is no visible evidence of any, for the markings which are seen are unobscured by haze or cloud on the planet. We must, therefore, conclude that *Mercury* is not habitable.

Next outward from the Sun we come to *Venus*. In size and density this planet is very like the Earth, and we might expect here, if anywhere upon the planets, we should find conditions suitable for life like our own. Until recently the rotation period was thought to be almost the same as that of the Earth, so that she would have the same alternation of day and night, and the fact that what markings are seen are of the dimmest, vaguest sort argues that a dense atmosphere, perhaps filled with clouds, covers the planet. In 1889, however, SCHIAPARELLI came to the conclusion that *Venus*, like *Mercury*, keeps the same side always toward the Sun, rotating once in exactly the same time in which she completes her circuit around the Sun. LOWELL's more recent observations confirm this view, and spectrograms of the planet taken at Flagstaff tend to establish the fact of very slow rotation. We may, however, question the validity of a proof which depends upon spectrograms taken in midday, when the sky spectrum, i. e. the spectrum of sunlight reflected by our own atmosphere, is superposed upon that of the planet, and masks the slight inclination which the planet's rotation might produce in the spectral lines.

The orbit of *Venus* is very nearly circular, so that, if the planet rotates exactly once in each revolution around the Sun, there is very little libration in longitude, and the conditions upon the sunward side and the side opposite must be even more contrasted and constant than upon *Mercury*. Professor LOWELL points out that the atmospheric currents would be practically constant, the lower currents being away from the point directly beneath the Sun to the point directly opposite. One effect of these conditions would be to continually carry away the moisture from the sunward hemisphere and deposit it in the form of snow and ice on the dark hemisphere. The low temperature prevailing there would cause the moisture to be frozen and so prevented largely from returning. This process kept up from age to age would finally deplete one hemisphere of its water and cover the other with a permanent coat of ice. Thus *Venus,* if these things are true, is an even more undesirable place of abode than *Mercury*.

We have not been very successful, thus far, in our attempt to find a place of comfortable abode away from the Earth. Let us try *Mars* next. Here we first find positive signs of similarity to the Earth. The atmosphere of *Mars* is much less dense than that of *Venus* or that of the Earth, and much more of permanent detail of surface may be seen than upon any other planet. We see here large areas of bluish green, which used to be called seas and oceans, but which are now thought to be regions where vegetation is abundant. Other large areas, covering more than half of the surface of *Mars,* are of a reddish orange color, and are thought to be great deserts. The polar regions are marked by white areas which increase and diminish with the seasons on *Mars,* and it is very natural to call these snow caps, from the likeness of their behavior to that of the polar areas of snow and ice upon the Earth. The day of *Mars* is only about forty minutes longer than ours; the year there is 687 of our days, or 669 of the Martian days. The axis of the planet is tilted out of perpendicular to the plane of its orbit by 23° 59′, only half a degree more than the tilt of the Earth's axis, so that the seasons on *Mars* will be almost the exact counterpart of our own, except that their length is nearly double ours.

The difficulties in the way of saying at once that *Mars* is habitable by beings like ourselves are three; the lack of heat from the Sun; the lack of atmosphere; and the lack of large bodies of water. Being 1.4 further from the Sun, *Mars* receives only half the heat that the Earth does, and this fact would argue that in the absence of a dense blanket of water-vapor to retain the heat, the temperature must be extremely low, too low in fact for ice to melt at all. The change of the polar caps contradicts this, and those who argue for low temperature are forced to suggest some other substance than snow to account for the caps. Carbon dioxide has been suggested by some as a substance whose crystals are as white as those of snow, and whose temperature of crystallization is much lower than that of water. But LOWELL points out that at pressures of anything like that of our atmosphere or less, carbon dioxide passes at once from the solid to the gaseous state. Water lingers in the intermediate state of a liquid. The Martian cap as it melts is surrounded by a deep blue band, which accompanies it in its retreat, shrinking to keep pace with the diminution of the cap. This is what we should expect if it were water. And if we are to bring in an extra amount of carbon dioxide, a far less increase over the amount found in the Earth's atmosphere would so add to the heat retaining power of *Mars's* atmosphere as to account for the apparently high temperature indicated by the observed seasonal changes.

Of the rarity of the atmosphere there is no question. The mass of *Mars* is so much smaller than that of the Earth that the force of gravity at the surface of the planet is too weak to retain an atmosphere of anything like the density of our own. Even the most ardent advocates of the possibility of life on *Mars* admit that if one of us were to be suddenly transported to that planet, he would probably die in a few minutes because of the rarity of the atmosphere. But it is claimed that beings like ourselves might gradually become accustomed to an atmosphere much rarer than ours, and this is probably true.

That water is comparatively scarce there, is also unquestioned. The spectroscopic observations of *Mars* at Flagstaff indicate very little, if any, absorption by water-vapor, and those by CAMPBELL at the summit of Mount Whitney show no trace of any at all. In fact, if LOWELL be right, it is this very scarcity of water which has brought about the evidence which comes nearest to proving that there are actually living, intelligent beings on *Mars*. Crossing the reddish-orange regions, which are considered deserts, in all directions is a network of narrow dusky lines, which their discoverer, SCHIAPARELLI, called *canals* (channels). They are so narrow and difficult to see that it is impossible to assign a color to them, but as they connect always with the bluish-green areas or with each other, it is probable that their color is the same as that of the large dark areas, bluish green, and is due to the same cause. They are extremely difficult to see, and many astronomers have not been able to see them at all. Others glimpse them as broader and hazier than they are drawn by SCHIAPARELLI and LOWELL. As a result there has been much doubt as to the real character of these markings. LOWELL does not hesitate to explain them as lines of vegetation along artificial watercourses; not the canals themselves, but the irrigated regions on either side of the canals. From his studies at Flagstaff, Arizona, at all the oppositions of the planet since 1894, LOWELL finds that the "canals" vary in visibility with the Martian season in such a way as to indicate progressive irrigation, as the water flows from the melting polar caps toward and even beyond the equator. Certain of the "canals" run north and south through the dark areas as well as the light ones, into the regions covered in winter by the polar caps. As the cap melts in spring there first appears a blue band at its edge. After a time the canals nearest this band become visible, then later those nearer the equator, the interval between the melting of the cap and the appearance of the canals being sufficient to allow for the time required, not only for the transference of water, but also for the springing up of vegetation, after the water has reached the irrigated region. The "canals" near the equator on either side have two periods of visibility each year, corresponding to the time when the water would reach them from the two polar caps at opposite seasons of the year. The "canals" as a rule are very straight, running on arcs of great circles from point to point on the globe of *Mars*.

After several of them meet at a common point, and in many cases at the intersection of two or more of them there appears a round dark spot, to which LOWELL gives the name "oasis." The apparent straightness of the "canals" has made astronomers skeptical of their reality, since on the Earth watercourses, whether real or artificial, are never straight. They invariably wind about, following the contour of a level or descending line. Either *Mars* has a very flat surface or the Martians are very wonderful engineers. Perhaps both statements are true. There is no evidence of mountains on the planet, for the terminator never has the jagged appearance which the mountains produce on the sunrise and sunset lines of the Moon. Clouds are very rarely conspicuous. I have sometimes seen misty patches over the dark areas, as if there were very thin clouds or fog there, but never enough to entirely obscure the surface of the planet beneath them.

On the whole, we must conclude that life on *Mars* would not be very satisfactory for beings like ourselves. That there may be life there, I would not like to deny. There may be intelligent beings, of a higher order even than ourselves, but of this there is no adequate proof. LOWELL in the "Conclusion" of his book "*Mars* and Its Canals," says "that *Mars* is inhabited by beings of some sort or other we may consider as certain as it is uncertian what those beings may be." With the last part of the statement we can certainly agree.

The satellites of *Mars* are so small,—not more than twenty or thirty miles in diameter,—that they must ages ago have lost all their heat and absorbed their air and water, so they are not the places for life.

Next in order, outward from the Sun, we come to the giant planet *Jupiter,* with his retinue of four large satellites and four small ones. The diameter of *Jupiter* is 86,000 miles, eleven times that of the Earth, but his rotation is so swift that the Jovian day is less than ten of our hours. His average density is only one-fourth of that of the Earth, i. e. a little greater than that of water. The surface is diversified by belts of red and purple and white running parallel to the equator. These do not suggest the appearance of land and water, but rather of cloud-zones, between which we see perhaps portions of the real surface. The best evidence we can get goes to show that

Jupiter has not yet cooled off enough to have a solid surface, but that it is still intensely hot and subject to continual changes. He is a sort of semi-sun, giving light and heat to his satellites to make up in part for the diminution of light and heat of the Sun at their great distance.

Interesting as the astronomical phenomena as seen from *Jupiter* would be, with the eight moons circling about him, producing total lunar and solar eclipses every day, we can hardly say that the giant planet is fitted for a place of abode. It is possible that on the satellites the conditions may be more like those on *Mars* and the Earth, but we can tell very little about them. The little we do know points to similarity to our own Moon, which we have found to be uninhabitable.

Saturn, the king of the planets, comes next in order, with his golden rings and numerous satellites. Surely this would be a glorious place to live, with the ten moons of as many different sizes and the great arch of meteor rings spanning the heavens. But we find that *Saturn* is in much the same condition as *Jupiter,* not yet cooled off. The low density of the planet,—less than that of water,—and the brightness of its surface,—greater than that which could be produced by the reflected light of the Sun,—indicate a high temperature. Of the conditions of the satellites we know almost nothing. *Titan,* the largest, approaches *Mars* in size, and might, so far as size is concerned, be an inhabited world.

The two outer planets, *Uranus* and *Neptune,* are too far from the Earth to allow us to learn much of their surfaces. *Uranus* has belts like Jupiter. *Neptune* has no perceptible markings on his surface. Both are denser than *Jupiter* and *Saturn* and of darker color. There is one argument which seems to be pretty conclusive against the habitability of these planets and that is the diminution of the Sun's light and heat at such great distances. As seen from *Neptune,* the Sun would have only one-thirtieth of its present apparent diameter and would give only one nine-hundredth as much light and heat. This would hardly be deemed sufficient to maintain life like ours.

We have omitted the asteroids, of which there are now nearly seven hundred known, and more being discovered every month, in our discussion of the condition of the planets. As the largest of these is not more than four hundred or five hundred miles in diameter, it is not probable that any of them are not warm enough, or possess atmosphere enough, to sustain life.

In the whole solar system, then, we find but one planet, *Mars,* on which the physical conditions seem to be suited to life like our own, and even there our constitutions would have to be considerably modified. Some of the satellites of *Jupiter* and *Saturn* may also, perhaps, be habitable, but of the condition of these we have almost no positive knowledge.

But how about the stars? Among the thousands, millions, and hundreds of millions of glittering orbs which the great telescopes reveal, are there no inhabited worlds? We can say of each one of these, which is visible to the eye or which the telescope reveals, that it is a sun, an intensely hot, glowing body, shining by its own light and therefore not an inhabitable world. How many satellites or planets there are, circling invisible around the stars, we can only infer by analogy, and we can only infer, again by analogy, that among the myriads of these invisible satellites there may be millions of worlds like our own.

PLANETARY PHENOMENA, MAY AND JUNE, 1911.

By Malcolm McNeill.

PHASES OF THE MOON, PACIFIC TIME.

First Quarter..	May 5,	$5^h\ 14^m$ A.M.	First Quarter.	June 3,	$2^h\ 4^m$ P.M.
Full Moon ...	" 12,	10 10 P.M.	Full Moon ...	" 11,	1 51 P.M.
Last Quarter .	" 21,	1 23 A.M.	Last Quarter..	" 19,	12 51 P.M.
New Moon ..	" 27,	10 24 P.M.	New Moon ..	" 26,	5 20 A.M.

The Sun reaches the summer solstice and its point of greatest north declination on June 22d at 5 A. M. Pacific time.

Mercury is an evening star at the beginning of May, but too near the Sun for observation. It passes inferior conjunction on May 5th and becomes a morning star. It reaches its greatest west elongation on June 1st. From that date it draws nearer to the Sun and by the end of the month has nearly reached superior conjunction. As a rule west elongations of *Mercury* do not afford a good opportunity for viewing the planet. But the present greatest west elongation, 24° 30′, is